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LIFE HISTORY AND HABITS OF THE MEALY PLUM APHIS.

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The mealy plum aphis (*Hyalopterus arundinis* Fabricius) has been recognized for many years as an enemy of plums, prunes, and to a lesser extent apricots in California. Since 1913 it has been especially severe in some regions, notably those in which artificial control for the pear thrips (*Taeniothrips pyri* Daniel) was not practiced.

ORIGIN.

The insect is European in origin, having been first described in 1794 by Fabricius. In North America it is widely distributed. According to Lowe (3)[1] it is present in Australia and New Zealand, Van der Goot (2) reports it from Java, while the United States Bureau of Entomology has records of its occurence in Japan. Specimens in the writer's collection taken on Arundo in Peru, by Mr. E. W. Rust, late of the Bureau of Entomology, appear to belong to this species but the lack of winged forms prevents certain determination.

HOSTS AND MIGRATORY HABITS.

In California plums and prunes of the *domestica* type are the favorite hosts, but apricots and Asiatic types of plums and rarely

[1] Figures in parenthesis refer to "Literature cited" on the final page of the bulletin.

almonds are attacked also. In Europe grape, peach, and nectarine are also attacked (Lowe).

From the deciduous-fruit hosts mentioned the mealy plum aphis migrates in early summer to plants of the genera Phragmites, Typha, and Arundo, and in the late fall there is a return migration to the fruit trees. This is the normal process of migration. Occasionally the writer has seen generations of aphids persist on plum until September, a habit that Lowe (3) records as not unusual in New York State.[1] The migratory forms are winged aphids and there are strong indications that they traverse long distances in passing from host to host, as summer colonies have been found in June many miles from the nearest winter hosts. Vast numbers of migrants are produced both in spring and fall, and the production of considerable numbers of summer migrants serves to distribute the species among the summer hosts. In California Phragmites and Typha are the known alternate hosts.

INJURY.

In the early summer months the aphids occur on the foliage, often crowding together in great quantities. (Pl. I.) The lower surface of the leaf is the preferred location, but the petioles and upper surface are frequently infested. The young fruit is less commonly attacked. The infested leaves are generally curled and discolored and glisten with honeydew deposits. (Pl. II.) The ground beneath the tree is often sprinkled with the whitish shed skins dropped by the aphids. The combined effect of myriads of aphids feeding simultaneously on the tree produces fruit of small size and an early drop. In the years 1915 and 1916 an unusual midsummer apical cracking of green prunes developed in California. Morris (4), after making observations in the Santa Clara Valley in 1915, opined that this cracking was due to aphis action. In 1916 the writer made some observations in Contra Costa County. He found that whereas on the whole cracking was more general on trees that previously in the season had been heavily infested with the aphis, it occurred also in other cases on trees which had escaped infestation. He could not conclude otherwise than that the aphis was not more than a contributing, or at least not the sole cause of the apical cracking in the prunes.

[1] Blakey (1), conducting his observations at Redditch, England, found no certain migration from the winter hosts, the aphids remaining the year around on fruit trees. In this connection it is of interest to note that he found the active cycle (from hatching of stem mother to oviposition) to extend in England from the beginning of May to the middle of October, 5.5 months, whereas in California the writer found the cycle to cover a period of 9 months (Mar. 1 to Nov. 30). The longer growing period enjoyed by the trees in California is of course responsible for this condition, and it is possible that the much dryer climate of California is concerned in the summer migration of the species to plants of a semiaquatic nature. The writer has observed that the aphids tend to remain on the fruit trees later into the summer in the more humid than in the more arid localities of California, while the occurrence on May 15 of large colonies on a summer host at Salton Sea (a very arid region) suggested that the aphids were living on this host the year around.

SYNONYMS.

1794. *Aphis arundinis* Fabricius, Ent. Syst., v. 4, p. 212.
1794. *Aphis pruni* Fabricius, Ent. Syst., v. 4, p. 213.
1886. *Aphis phragmiticola* Oestlund, List Aphid. Minn., p. 44.
1911. *Hyadaphis umbellulariae* Davidson, Jour. Econ. Ent., v. 4, p. 559.

BIOLOGY.

THE EGG.

Size 0.55 by 0.27 mm. The newly laid egg is pale green, covered with conspicuous silvery filaments excreted by the oviparous female. It darkens rapidly and after about 5 days is shining black; the threads, however, remain silvery.

LOCATION ON TREES.

The eggs are laid almost invariably in the axils of lateral buds of year-old or 2-year-old wood. Rarely more than three eggs are to be found to a single bud group. Occasionally eggs are placed in small scars or wrinkles in the bark of twigs.

HATCHING.

In 1916 hatching commenced about March 4, and continued for about two weeks. At this time most prune varieties were just starting to leaf, but the Myrobalans were in full leaf; nevertheless hatching was no earlier on the latter trees than on other plums and on apricots.

THE STEM MOTHER.

DESCRIPTION.

Newly hatched.—Pale green; eyes dark red; antennæ and legs pale gray; dorsum of head with a median longitudinal narrow pale green stripe; beak gray. Form oval.

Antennæ one-fourth the length of the body, 5-jointed. Comparative lengths: I, 0.03 mm.; II, 0.035; III, 0.045; IV, 0.05; V, 0.11 (0.060 plus 0.050); beak reaching to third abdominal segment, 0.21 mm. in length; cornicles minute raised pores. Style rounded. Length of body 0.63 mm.; width of body 0.39 mm.

During the first and second instars the color darkens and the dark markings on the head gradually disappear. The characteristic longitudinal stripes of darker green appear during the third and fourth instars. There are 3 of these, 1 mediodorsal and 2 dorsolateral. The tarsi, apices of tibiæ, cornicles, tip of beak, and distal third of the antennæ of the growing nymph become gray.

After the second molt the nymph assumes an elongate shape, and there appears on the sides and at the abdominal sutures a pruinose "meal." This "meal" is much more scanty and less conspicuous in the stem mother than in later forms.

Adult.—Yellowish-green with three longitudinal green stripes on dorsum; eyes dark red; antennæ pale green, distal joint dark gray; cornicles pale, dusky at apex; tarsi dark gray; style pale yellowish green; apex of beak blackish. Form elongate oval, comparatively flat; newly molted individuals carinate.

Antennæ on very short frontal tubercles, barely one-third the length of the body, 5-jointed. Comparative lengths: I, 0.075 mm.; II, 0.06; III, 0.30; IV, 0.14; V, 0.22 (0.08 plus 0.14). Beak, length 0.26 mm., reaching to second coxæ; cornicles, 0.045 mm.; style, 0.17 mm. Cornicles wartlike, style ensiform. Prothorax and all abdominal segments bearing small, pale, lateral tubercles. Body bearing a sparse, inconspicuous clothing of granular "meal," most abundant at the sutures. Length of body (style included), 2.39 mm.; width of body, 1.06 mm.

HABITS AND LENGTH OF NYMPHAL LIFE.

After hatching, the young aphids seek out buds, often massing on those most advanced, and contrive to penetrate to the inner portions. On unopened buds they feed on the tender apical portions and numbers of them die in such situations. Newly-hatched aphids move awkwardly on rough spiny leaf surfaces and frequently fail to make headway. This was observed especially in connection with Myrobalan plum leaves, and perhaps explains the fact that the stem mothers on this tree have a high percentage of mortality in their early stages.

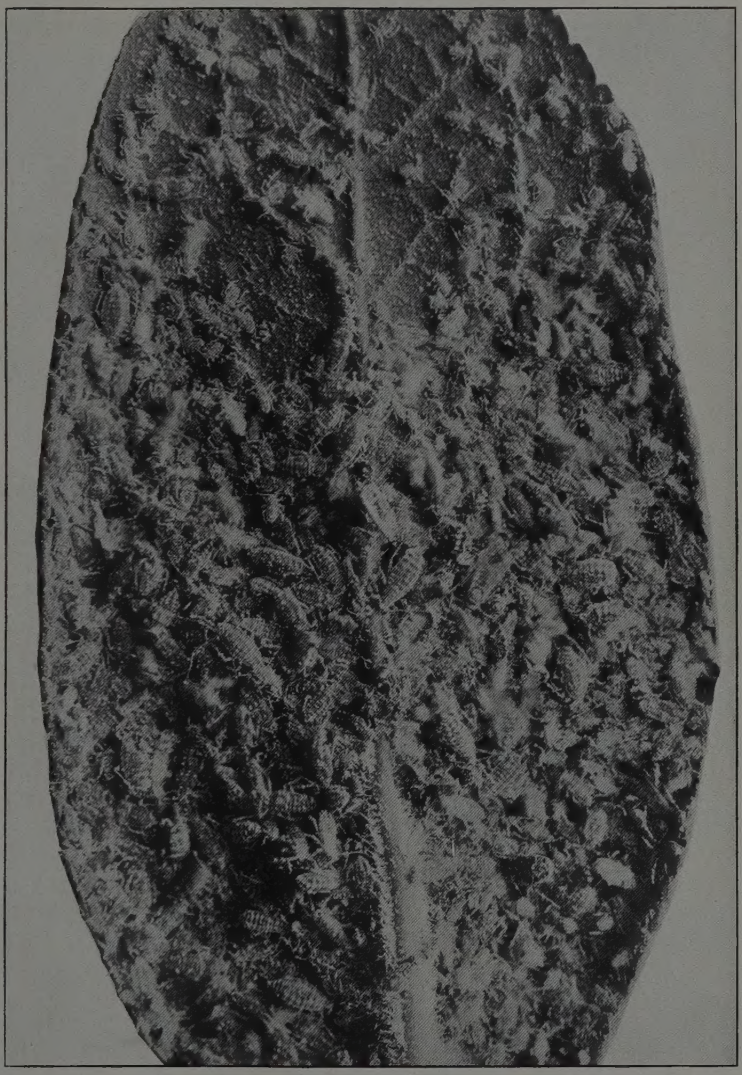
After the blossoms shoot out the aphids feed on the petioles or on the outside of the sepals. In the leaf bud they feed generally on the under (outer) surface of the unfolding foliage and less abundantly on the reverse side. A favored point is that at the junction of sepal and petiole on the flower stalks.

The first stem mothers matured on the plums at time of full bloom (March 19, in 1916), their growth being the more rapid on forward trees. On March 25 it was estimated that on the most advanced trees 85 per cent of the aphids were mature, while on the most backward only 20 per cent were full grown. At this time the mature stem mothers were on the underside of the leaves; none were remaining on the fruit stalks. On March 28 virtually all stem mothers on forward trees were mature; on most backward trees 50 per cent were still immature. By April 5 no more immature stem mothers were found.

Five stem mothers raised on potted Myrobalan seedlings developed in from 13 to 17 days. This time is perhaps less than in the average orchard, since the quality of food available for the newly-hatched aphid is often poor, while the seedlings were well in leaf at the time the experimental eggs hatched. It should be stated that the temperature in 1916 during the first part of the development of the stem mother was higher than usual for that time of year.

REPRODUCTION.

The stem mothers deposit on an average about 4 young a day during a period of from 3 to 5 weeks. The rate of fecundity rises rapidly at first, maintains an even zenith for some three weeks, and then rapidly declines. Stem mothers may live for as long as three weeks after they have deposited their complement of young.



THE MEALY PLUM APHIS (HYALOPTERUS ARUNDINIS).

Colony of aphids on lower surface of leaf. Enlarged.

THE MEALY PLUM APHIS.

Infested plum foliage.

THE SPRING FORMS.

Six wingless generations, in the maximum-generation series, were bred from April to June during 1916. An unusually hot wave occurred June 6, and killed all of the individuals of the seventh and eighth generations in the cages. It has been determined, however, that wingless generations may persist on the winter hosts through the summer as late as September, but apparently they can not produce true sexes. In the maximum series all second-generation individuals were wingless, in the third generation 1 out of 29 was winged, none of the fourth or fifth generations were winged, while the majority of the sixth and seventh generations were wingless. All the individuals in this series were bred on Myrobalan plum.

SPRING WINGLESS FORMS.

Description.

Newly hatched.—Pale yellowish-green; eyes dark red; rims of cornicles dusky. Appendages hyaline greenish-white. Form elongate oval.

Antennæ 5-jointed, half as long as body. Comparative measurements as follows: I, 0.03 mm.; II, 0.025; III, 0.11; IV, 0.06; V, 0.175 (0.05 plus 0.125). Beak reaching third coxæ, 0.22 mm. long; cornicles wartlike, 0.025 mm. long. Style rounded. Length of body, 0.50 mm.; width of body, 0.22 mm.

In the first instar the general color darkens, but it is never as dark as that of the stem mother; the tarsi, last antennal joint, and tip of beak become dark grayish-black. After the first molt a conspicuous "meal" is secreted in four longitudinal rows of circular areas on the body dorsum. This "meal" is more abundant on the first and fifth abdominal segments than elsewhere. The three longitudinal green stripes described in the stem mother appear less distinct in later generations. After the second molt the body is elongate oval. The aphids have a carinated appearance following each molt.

Adult.—Light green; eyes dark red to black; antennæ pale hyaline green, apex gray; legs hyaline greenish-white, tarsi and tibial apices gray; cornicles somewhat dusky in apical half; cauda light greenish-white. Beak pale, tip blackish. "Meal" as in larva, increasing with age of insect. Form elongate oval.

Antennæ on frontal tubercles, 6-jointed, two-thirds as long as body; comparative measurements as follows: I, 0.085 mm.; II, 0.075; III, 0.39; IV, 0.24; V, 0.225; VI, 0.445 (0.105 plus 0.340). In later generations filament of VI is longer in proportion than in earlier. Beak reaching second coxæ, 0.30 mm. long. Cornicles imbricated rather inconspicuously, constricted near base, somewhat enlarged in middle, mouth not flaring; length, 0.115 mm. Cauda ensiform, 0.17 mm. long. Body length, 2.2 to 2.8 mm.; width, 1.2 mm. Small, pale, blunt lateral tubercles occur on the prothorax and on each abdominal segment. Body armed with very few hairs.

Duration of Nymphal Stages.

Records of the development of the wingless forms were made both on caged trees and in the orchard. Myrobalan and Agen (*French*) prunes were used for hosts. The development was similar on both

hosts, the aphids being retarded on weaker trees. The instars occupied, on the average, equal periods of time, except that the fourth was slightly shorter than any one of the others.

Forty-five individuals of the second generation were observed during the period March 27–May 4, the majority developing during the period March 30–April 22. The average growing period was 12.6 days, the maximum 18, and the minimum 10.

Between April 11 and May 30, 34 third-generation wingless individuals developed in an average of 11.8 days, the maximum and minimum periods being, respectively, 18 and 9 days.

Individual records of generations 4 to 7 were made chiefly from the maximum-generation series and might be grouped best in tabular form as follows:

TABLE I.—*Development of spring wingless generations of the mealy plum aphis. Walnut Creek, Cal., 1916.*

Generation.	Dates included.	Number of individuals.	Developmental period.		
			Average.	Maximum.	Minimum.
			Days.	*Days.*	*Days.*
IV....	Apr. 23–May 16	10	9.9	14	9
V.....	May 3–May 18	27	11.1	14	10
VI....	May 14–May 27	30	12.7	16	11
VII...	May 26–June 3	10	[1] 10	11	9

[1] June 7, five fourth-instar wingless individuals died because of an excessive heat wave. Had these matured, the average developmental period would have been slightly lengthened.

MAXIMUM AND MINIMUM GENERATIONS.

A maximum-generation series of first-born aphids (wingless) is shown in the table following:

TABLE II.—*Development of maximum-generation series of the mealy plum aphis. Walnut Creek, Cal., 1916.*

Generation of individual.	Date of birth.	Date of fourth molt.	Developmental period.
			Days.
I.....	Mar. 11	Mar. 28	17
II.....	Mar. 30	Apr. 11	12
III....	Apr. 11	Apr. 23	13
IV.....	Apr. 23	May 3	10
V.....	May 3	May 14	11
VI.....	May 14	May 26	12
VII....	May 27	June 6	9

Thus in the space of 11½ weeks seven complete generations occurred. Had it been possible to have continued the series until winter, certainly 10 more generations would have been produced. The adults

usually deposit young within a very few hours after shedding the final skin.

A minimum-generation series of last-born aphids is indicated below:

TABLE III.—*Development of minimum-generation series of the mealy plum aphis. Walnut Creek, Cal., 1916.*

Generation of individual.	Date of birth.	Date of fourth molt.	Developmental period.
			Days.
I.....	.....	Mar. 31	.....
II.....	Apr. 21	May 3	12
III.....	May 29	June 11	13
IV.....	July 1	July 12	11

These four generations were completed in about four months, or over a month longer than the seven generations of the first-born series.

The period of reproduction as indicated in the foregoing table varied from 20 to 26 days.

REPRODUCTION.

Observations were made on the reproduction of individuals of wingless generations 2 to 5 inclusive. Adults of the second generation, for a total reproductive period of from 4 to 5 weeks, averaged about 4 young daily, producing the first three weeks a daily average of 6 young. The later generations were less prolific, fourth and fifth generation individuals not averaging above 2¼ young per day. Ten young were deposited within 24 hours on several occasions, but on no occasion was this number exceeded. The rise and decline in fecundity was in the main similar to that found in the case of the stem mother.

HABITS OF SPRING GENERATIONS.

The aphids of the second generation, when newly born, dispose themselves in groups, close by the parent, on the underside of the leaf. After the first molt many remove to other leaves and this is the beginning of the migration from leaf to leaf and branch to branch. Second-generation larvæ and adults prefer to suck the rib tissues of the leaf. Owing to the rapidity of reproduction and consequent crowding, the aphids of later generations have little choice of location and feed at any point on the lower surface of the leaves or on petioles. If the lower surface of a leaf is entirely occupied many larvæ will be found feeding on the upper surface, in some cases apparently in preference to seeking other less crowded leaves.

In 1916 infested prune leaves began to curl at the beginning of April, such leaves having one or more colonies of adult stem mothers and first-instar young. As April progressed the leaf-curl became more and more pronounced and the colonies increased rapidly.

About the middle of the month the most heavily infested leaves began to have a yellowish appearance in the form of blotched areas at the points where the aphids were most abundantly settled. On April 21 a few leaves were found to have their under surfaces quite covered with feeding aphids, and at the end of the month such leaves were abundant, while twigs and limbs were covered with a sticky "honeydew," and here and there young fruits were coated with this substance. During May and June this condition was greatly aggravated in the orchards examined.

The spring winged form first appeared April 21, and throughout May and June increased in numbers, and after the middle of May there was a corresponding decrease in the numbers of wingless adults produced. By July 1 the mature wingless individuals had diminished greatly in quantity and thereafter their numbers dwindled so that by the middle of August none were to be found. In no instance in 1916 was an infestation prolonged beyond this date, but in 1914 in the same locality a small but vigorous infestation occurred throughout September, later becoming annihilated by natural enemies.

In the rearing cages it was found that the transfer of newly born young was very frequently attended by the loss of the insect, and in most cases the adult was transferred when it was desired to make observations on a new plant. Several transfers of larvæ and adult wingless individuals from plum to apricot failed, while others resulted successfully. Infested apricot leaves did not curl as badly as those of prune and plum.

THE SPRING MIGRANT.

Description.

In the first three instars the nymphs of the migrants do not differ from those of the wingless spring form, except that the third-instar individuals are somewhat narrower.

Pupa.—Light green; eyes dark red; tarsi and apex of beak dark gray. On the body ground color is superimposed a narrow dorsomedian stripe of darker green. Thorax broadened to twice the width of the prothorax. Wing pads yellowish white. Body with pruinose covering as in wingless nymph.

Adult.—Light green; eyes red; antennæ light gray, basal portion of third joint hyaline yellow; head, thoracic lobes, and sternum dark grayish black; scutellum yellowish brown; prothorax, sides of thorax, and wing insertions greenish yellow; wings hyaline, stigma and veins gray; legs pale greenish yellow, apices of tibiæ and the tarsi dusky gray; abdomen and style pale green or greenish yellow; cornicles pale at base, dusky at apex. Beak pale, extreme tip dusky.

Form elongate, the abdomen with parallel sides.

The dorsum and sides are covered with white pruinose "meal," on the abdomen the "meal" occurring in transverse bars.

Antennæ four-fifths as long as body, on frontal tubercles. Comparative measurements as follows: I, 0.08 mm.; II, 0.06; III, 0.405; IV, 0.26; V, 0.21; VI, 0.48 (0.10 plus 0.38). Beak reaching a little beyond anterior border of mesosternum, 0.26 mm. long. Wings 2.5 mm. long. Cornicles faintly imbricated, shorter than in wingless female, barely twice as long as broad at base, slightly constricted near base, in length 0.08 mm. Style ensiform, 0.15 mm. long. Length of body, 1.61 to 2 mm.; width, 0.66 mm.

Lateral tubercles as in wingless form; first antennal joint somewhat gibbous.

Sensoria.—On III, 23 to 30; on IV, 4 to 10; on V, 1 to 2; on VI, usual apical group. Sensoria of unequal size, not at all arranged in longitudinal rows, but rather in spirals.

Duration of Nymphal Stages.

Eight winged spring migrants developed in an average of 14½ days, the developmental period ranging from 13 to 18 days. The winged form therefore develops more slowly than the wingless, due to the increased duration of the fourth instar.

Reproduction.

The migrants commenced to reproduce on the cat-tail rush (Typha) a few days after they settled. In many cases migrants were found to settle, remain for several days, and finally die without reproducing and only a small percentage of those settling reproduced. Most of them remained a few days and then departed. Spring migrants in only one instance out of 76 deposited young on caged plums. In this instance the three young born refused to feed on the plum (Myrobalan). In this connection it might be said that all attempts to induce wingless forms of earlier generations to settle on Typha failed. Migrants placed in small dishes and provided with plum and cat-tail foliage in no instance deposited young and in extremely few instances did migrants placed on cat-tail deposit young. Unfortunately it was not possible to obtain Phragmites for similar tests.

The migrants may remain on the winter host foliage for several days before taking flight, especially if the weather be cool and cloudy.

Field observations indicated that the migrants produced young at the rate of about five every two days at first, and later at a slower rate. On Typha it appeared that the maximum number of young per migrant rarely exceeded 20 and, discounting all migrants which failed to deposit, averaged not much over five. This must have been abnormal, as examination of individuals disclosed the presence of many more embryos than were extruded. It is possible that Typha does not prove an invigorating food for the migrant and this point is perhaps elucidated below in the paragraphs on migrations.

Migrations.

Phragmites and Arundo have long been known as alternate hosts of the mealy plum aphis; in fact the species has been described as new from both of these hosts. In California enormous infestations

have been observed on the former in swampy regions, sometimes removed many miles from any winter hosts. On the other hand, Typha grows in abundance close to prune orchards and yet, considering the enormous production of spring migrants throughout May, June, and July, the later infestations on near-by Typha are in the aggregate exceedingly small. The writer has seen clumps of *Typha latifolia*, growing not 30 feet from prune trees on each of which thousands of winged forms were being developed, receive only a few dozen migrants and perhaps have not over 6 out of 100 blades colonized by their progeny. It is true that when once established a colony on Typha increases rapidly, but it is also evident that the migrant fails to do justice to her reproductive capabilities on this plant.

That the migrants fly long distances to seek their alternate hosts, especially Phragmites, is the conviction of the writer.

The spring migrants settle on Typha near the apex of a strongly-growing blade and station themselves parallel to its long axis. The wingless forms later take up this same position. After the migrants have extruded a few young the whitish meal is excreted in greater abundance. On Phragmites the colonies are similarly disposed. On three occasions the writer observed heavy summer infestations on the reed *Phragmites communis* L. On July 5, 1917, along the banks of the San Joaquin River about 15 miles west of Stockton, Cal., this plant was heavily attacked. Among the colonies occurred a few pupæ and winged forms of a winged summer form. *Typha latifolia* growing among the infested reeds was not attacked. On August 13, 1917, at Benicia, Cal., clumps of reeds growing in swampy ground near San Francisco Bay bore heavy infestations of the aphis and the summer winged form was abundant. Plants of Typha growing among the clumps of Phragmites were sparingly infested. On May 15, 1918, heavy infestations were observed on *Phragmites communis* growing on the west shore of the Salton Sea, in southern California.

These observations indicate that Phragmites is the preferred summer host plant.

The summer winged aphids serve to distribute the species among the reeds. They do not differ in appearance or structure from the spring migrants produced on the winter hosts.

Fall migrants appeared both in 1915 and 1916 on Typha about October 15, and continued until the end of November. Males appeared the last week of October and throughout November. The small yellowish pupæ of the latter are easily distinguishable on the cat-tails from the green pupæ of the fall migrant. Mature fall migrants remained on the summer host for a day or two before departing.

Although migrations from Typha were traced with apparent certainty in the fall of 1915, in the following year so few fall migrants were produced on local Typha under observation that they were out of all proportion to the great numbers of winged forms which began to appear in the prune orchards near Walnut Creek toward the end of October, and it was certain that the great majority of migrants were coming from a considerable distance.

THE SUMMER WINGLESS FORMS.

DESCRIPTION.

Newly hatched.—Similar to that of spring wingless form, but more yellowish. Form elongate.

Adult.—In color similar to those of spring wingless, but smaller in size and narrower in shape.

Antennæ about two-thirds body length. Comparative measurements as follows: I, 0.08 mm.; II, 0.045; III, 0.26; IV, 0.16; V, 0.155; VI, 0.40 (0.08 plus 0.32). Beak reaching second coxæ, 0.26 mm. long. Cornicles more cylindrical than in spring wingless form, inconspicuously imbricated, 0.07 mm. long. Style 0.135 mm. long, shaped as in spring wingless form. Length of body, 1.6 to 2 mm.; width of body, 0.65 mm.

Measurements from specimens of what appears to be *H. arundinis* collected in April on Arundo in Peru by Mr. E. W. Rust were noticeably greater, but similar in proportions.

The lateral tubercles are inconspicuous.

DURATION OF STAGES.

Eighteen first-generation (progeny of migrant) individuals in the period May 29–August 20 matured on Typha in an average of 14.6 days, the period of growth ranging from 12 to 18 days. Between June 17 and July 30, 15 aphids of the second and third summer generations developed in an average of 15.8 days, with a range of from 9 to 18 days, while 17 fourth-generation individuals developing between July 26 and August 27 averaged 12.2 days, with a range of from 9 to 16 days. Aphids maturing in September developed in an average of 14 days. All the individuals recorded above were wingless. There is apparently a maximum of as many as 10 wingless summer generations and a mimimum of 3. Molts occurred about as in the spring wingless forms.

HABITS OF SUMMER WINGLESS FORMS.

Colonies are located on both sides of the blades, chiefly on the outer half, occasionally on the basal half of the leaf. In September, 1915, several colonies of over 200 wingless individuals were observed on single blades of Typha at Walnut Creek, and about the end of this month the aphids reached their maximum abundance. This latter condition was repeated in 1916, although the colonies were never as

large as the year previous. As has been noted, the aphids lie parallel to the length of the blade. They move off at slight disturbance and much difficulty was experienced in transferring individuals, owing to their failure to settle on a new plant.

Toward the end of October the blades frequently turn yellow, causing the aphids resident thereon to assume a straw-colored appearance.

The aphids frequently deposit a little circle of "meal" around them on the surface of the blade, a habit similar to that practiced on the same host by a species of white fly. On leaves of Phragmites the aphids congregate in large masses on both surfaces, lying parallel to the long axis of the leaf. The central portion of the leaf is colonized first and as the colony increases in numbers the infested area approaches the margins.

THE FALL FORMS.

There are three fall forms—the fall viviparous migrant, the male, and the sexual oviparous female. The first two fly to the winter hosts, after which the viviparous migrants deposit the sexual oviparous females.

FALL MIGRANT.

Description.

The immature stages do not differ materially from those of the spring migrant.

The adult insect, aside from being slightly smaller and having the antennæ, legs, and style more dusky, is similar to the spring migrant. Form elongate.

Antennæ on somewhat gibbous frontal turbercles, about two-thirds as long as the body. Comparative measurements as follows: I, 0.07 mm.; II, 0.06; III, 0.39; IV, 0.235; V, 0.175; VI, 0.48 (0.10 plus 0.38). Beak reaching a little beyond anterior border of mesosternum, 0.26 mm. in length. Wings 2.6 mm. in length. Cornicles shaped as in spring migrant, 0.075 mm. long. Style ensiform, 0.16 mm. long.

Sensoriation and tubercles as in spring migrants.

Reproduction and Habits.

The migrants normally locate on the underside of the leaves (of the winter host), but those that arrive latest in the season often find the leaves blown off by winds and perforce settle on the twigs. Frequently they feed for several days before producing young. In experimental cages inclosing Agen (*French*) prunes and Myrobalan plums 14 was the highest number of young laid by a single migrant, and the average was about 8 (excluding about 20 per cent of the individuals which died without bearing progeny). The migrants were more prolific on Agen (*French*) prunes than on Myrobalan plums. In the field it appeared that from 12 to 35 young sexual females are produced normally, with an average of about 20, on French prunes.

The young were produced within about 12 days (in the cages mostly within 7 days) and at a rate of from 2 to 3 a day. The migrants, after they had extruded their complement of young, remained settled for as long as two weeks.

MALE AND OVIPAROUS FEMALE.

Male.

DESCRIPTION.

Pupa.—Noticeably smaller than that of the fall migrant, light yellow in color; eyes dark red; tarsi and distal antennal joint dusky gray. Form elongate.

Adult.—Light clay yellow; head, antennæ, prothorax, thoracic lobes, scutellum, legs, cornicles, and style brownish-black; eyes dark red; stigma light greenish-gray; veins of wings brown; abdomen with a dorsomedian longitudinal row (segments 1 to 5 inclusive) of subcircular gray spots, similar lateral spots on segments 1 to 3 inclusive, and with cross bars of similar color on segments 6, 7, and 8; genital plate and organs dark gray; beak pale yellow, tip brownish black. The male is almost devoid of "meal."

Antennæ on gibbous frontal tubercles, three-fourths the length of the body; comparative measurements as follows: I, 0.08 mm.; II, 0.07; III, 0.38; IV, 0.25; V, 0.23; VI, 0.46 (0.09 plus 0.37). Wings 2.3 mm. long. Cornicles vase-shaped, narrowed close to base, faintly imbricated, 0.085 mm. in length. Style conical, 0.10 mm. long. Beak reaching a little beyond anterior mesosternal border, 0.30 mm. long. Length of body, 2.05 mm., width, 0.68 mm.

Circular sensoria are distributed along the antennal joints much as in the spring and fall migrants. They are much more numerous, there being from 38 to 53 on III, 19 to 29 on IV, 9 to 18 on V, and the usual apical group on VI.

Oviparous Female.

DESCRIPTION.

Newly hatched.—Light green, appendages hyaline; eyes red. Form oval.

The immature females are bright green with a very scant covering of "meal."

Adult.—Greenish yellow; eyes dark red; distal half of antennæ, cornicles, and tarsi gray; beak pale yellow, tip brown. The coating of "meal" is not so conspicuous as in the earlier forms, in this respect resembling the stem mother. Form elongate oval, rather flat.

Antennæ not quite half as long as body, comparative measurements as follows: I, 0.06 mm.; II, 0.035; III, 0.145; IV, 0.06; V, 0.085; VI, 0.245 (0.05 plus 0.195). Beak reaching second coxæ, 0.25 mm. long. Cornicles cylindrical, twice as long as wide at base, faintly imbricated, 0.05 mm. long.

Style conical, 0.08 mm. long. Length of body, 1.18 mm.; width, 0.52 mm.

The thickened hind tibiæ bear a large number of small circular sensoria.

Nymphal Stages.

For the male the nymphal stages were not observed closely, this form having been very rare on the cat-tails in 1916. From such observations as took place it appears safe to say that both males and fall migrants develop in about three weeks. The development of oviparous females was observed in 1916 on both Agen (*French*) prunes and

Myrobalan seedlings. Within the period October 20–November 23, 40 oviparous females matured in an average of 19.1 days, the period of development ranging from 16 to 22 days. On Myrobalan plum the development was slightly slower than on Agen (*French*) prunes.

Habits and Oviposition.

The females feed normally on the under surface of the leaves, but occasionally also on tender stalks, especially of sucker growth. The males frequently arrive before the females are mature and settle down beside the immature aphids. Copulation takes place very soon after the female casts her fourth skin, and a male may copulate with more than one female. As the males are much less abundant than the females this practice is probably common and was often noticed in the cages. Toward the middle of November, 1916, large numbers of immature females were blown off the trees by winds and perished. In some orchards this only thinned out the infestation to a small degree, as plenty of mature females had been observed previous to the coming of the high winds, but in others wherein the sexes were not so advanced it destroyed the majority of the aphids. The oviparous females bear only a scant coat of "meal" and may be easily confused in the orchard with those of *Phorodon humuli* Schrank and *Aphis cardui* Linnæus, both of which are contemporaneous with *arundinis*. They are less likely to be confused with the plump reddish-brown oviparous form of *Rhopalosiphum nymphaeae* Linnæus.

As a rule the female commences oviposition within 24 hours of copulation, but this was delayed in some cases as long as 5, and in one instance 10 days. In cages never more than 2 eggs, and more often only 1, were laid in one day by a single aphid.

Sixteen females laid an average of 4.1 eggs in the period November 9–December 18. In the early part of this period the average was 6, while toward the end it was 3.5. Not over 7 eggs were deposited by one female. There was a marked tendency to deposit the eggs over a long period—as much as three weeks—and the females after depositing an egg or eggs on the stems generally returned to the leaf, remaining there until the time for the deposition of the next egg. The females usually died within a week of depositing their last egg, but in some cases lived longer, and one aphid lived beyond three weeks. It appeared, however, that those that persisted had not rid themselves of all their ova, as they did not have the shrunken appearance of sterile aphids.

NATURAL ENEMIES.

The mealy plum aphis, both on winter and summer hosts, is preyed upon by a large series of natural enemies. As early as March 17, 1916, a few eggs of Syrphidae and Chrysopidae were observed de-

posited near the growing stem mothers on plums. Throughout April lampyrid beetles (*Podabrus comes* Le Conte, *P. binotatus* Le Conte var., and *Telephorus divisus* Le Conte) appeared locally. During May syrphus-fly larvæ (especially *Catabomba pyrastri* Linnæus) and ladybird adults and larvæ (especially *Hippodamia convergens* Guérin) abounded, as did also a few hemerobiid larvæ. Nevertheless these predators made little apparent headway in reducing infestations.

Observations made in June, 1915, indicated that *Hippodamia convergens* was by far the most beneficial of the ladybirds.

The Typha colonies were preyed on by the larvæ of Syrphus; those on Phragmites by beetles of the Hippodamia group and by Leucopis larvæ; and late in the fall the sexual females were attacked by syrphids and Triphleps.

Internal parasitism in the writer's opinion is of very rare occurrence. Occasionally he has observed parasitized specimens in nature.

CONTROL SUGGESTIONS.

There are two especially vulnerable periods in the annual life cycle of the mealy plum aphis—one in early spring when the stem mothers are growing and the other in late fall when the sexual females are developing on the winter hosts. Unfortunately at these two periods the enemies of the aphis are very scarce, but the aphis itself is more easily destroyed than at other times by artificial substances. Both the stem mothers and the oviparous females have a scant protective covering of "meal" and both live for the most part on exposed surfaces of the plant, whereas the aphids of the spring and summer generations bear a comparatively thick coating of meal and live in great part in curled foliage. Contact insecticides, which have little effect on aphids of the intermediate generations, easily destroy the stem mothers and the egg-laying females.

SUMMARY.

The mealy plum aphis in California is a decided pest of plums, prunes, and, to a lesser degree, apricots. Besides devitalizing the trees it causes small-sized fruits and early drops, and is probably concerned in a measure with apical cracking of prunes.

In 1916 winter eggs hatched between March 4 and 18 and early stem mothers began reproduction about March 20. It appeared that normally from 3 to 5 generations were raised on the winter hosts, but rarely series of wingless generations persisted until the fall. The aphids of the earlier generations were mostly wingless like the stem mothers, and the individuals of the later generations mostly winged, and after the middle of June virtually all the insects produced developed wings.

Migration to the summer hosts, Phragmites and Typha, began the last week in April and continued until August, the great body traveling in early June. On these hosts about 10 generations took place, continuing up to November. The vast majority of aphids to be found during the summer were wingless, but winged parthenoparous individuals were also produced on the summer host plants and these served to distribute the species among these plants. About the middle of October and for six weeks succeeding, winged sexuparous migrants and winged males were produced and these flew to the fruit trees whereon the sexuparae proceeded to deposit sexual females. The sexes were most abundant during the forepart of November, and were to be found as late as the middle of December.

Oviposition took place throughout November and December. the majority of ova having been placed before December 10.

The foregoing data are based on observations made at Walnut Creek, Cal., between August, 1915, and December, 1916.

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